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EDUCATION

Docent, Engineering Geology, 2000, Royal Institute of Technology, Sweden. The Swedish academic title Docent corresponds to the level of Senior Lecturer (UK) or Associate Professor (US).

Ph.D. Engineering Geology, 1995, Royal Institute of Technology, Sweden. Thesis title: "Coupled Stress-Flow Properties of Rock Joints from Hydraulic Field Testing"

Technical Licentiate, Rock Mechanics, 1990, Luleå University of Technology, Sweden

Ms. Geotechnology, 1988, Luleå University of Technology, Sweden

CURRENT POSITION

1998-present: Geological Scientist (Staff Scientist level since 2004), Lawrence Berkeley National Laboratory, California.

PREVIOUS POSITIONS AND WORK EXPERIENCE

1996-1998	Post-doctoral research at Lawrence Berkeley National Laboratory, Berkeley, California
1991-1995	Research and teaching at Royal Institute of Technology, Stockholm, Sweden
1988-1990	Research and teaching at Luleå University of Technology, Sweden
1986-1987	Seasonal employment as Rock Mechanics Consultant at LKAB's mining company, Malmberget, Sweden.

RESEARCH ACTIVITIES

Research on **coupled thermal, hydraulic, mechanical and chemical (THMC) processes in geological media** with special emphasis on the **hydromechanical (HM) coupling**. The coupled phenomena in fractured rock, soil or clay are studied through *in situ* field experiments and numerical modeling of those experiments. Two numerical simulators have been developed 1) **ROCMAS**—a finite element code for modeling of coupled THM processes in unsaturated and saturated medium, 2) **TOUGH-FLAC**—a simulator using sequential coupling techniques for analysis of coupled THM processes under multi-phase flow conditions. Currently collaborative efforts include coupled THMC processes with coupling of **FLAC** to the reactive transport simulator **TOUGHREACT**, as well as linking the TOUGH multiphase flow and heat transport simulator to a number of geomechanical simulators leveraging on previous success in TOUGH-FLAC.

Current special research topics:

- **Deep underground injection of CO_2**: rock mechanical aspects and coupled HM processes including potential fault activation and induced seismicity.
- **Hydraulic fracturing and stimulation associated extraction of methane gas from tight rock (shale):** Coupled fluid flow and geomechanical modeling of hydraulic fracturing and potential fault activation.
- **Coupled THM and THMC processes around nuclear waste repositories:** Unsaturated/ saturated bentonite and fractured rock systems, two phase flow conditions, stress and chemically induced permeability changes in fractured rocks and swelling of bentonite.
- **Coupled THM and THMC processes in geothermal reservoirs:** Injection/production induced seismicity and surface deformations.
- **Coupled geomechanical modeling of hydrate-bearing sediments:** Mechaincal stability of hydrate-bearing sediments during gas production.
- **Coupled THM processes associated with compressed air energy storage (CAES) in underground caverns:** Thermodynamics and geomechanics associated with compression and decompression in storage operations.
- **Hydraulic injection in rock fractures:** Coupled HM phenomena during well testing and hydraulic fracturing stress measurements.

Coupled thermohydromechanical analysis of the following major sites and field experiments:

- Coupled reservoir-geomechanical modeling of the **In Sala** industrial CO2 storage site, Algeria (2007-present).
- Coupled THM analysis of induced seismicity at **The Geysers** Geothermal field, California (2006-Present).
- Full Scale Emplacement (FE) Experiment, **Mont Terri**, Underground Research Laboratory, Switzerland (2012-Present). A large-scale heater test in a bentonite-buffer and rock (Opalinus clay) system.
- Engineered Barrier System (EBS) experiment at **Horonobe Underground Research Laboratory**, Hokkaido, Japan (2013-present). A heater test for a bentonite-backfilled and rock (mudstone) system.
- Hydromechanical modeling of major fault reactivation during the 1960 **Matsushiro** Earthquake Swarm at Matsushiro Japan (2006-2007).

- Hydraulic injection tests and mechanical measurements at the **Coaraz** fractured rock site in France (2004a-Present).

- Drift Scale Test (DST), **Yucca Mountain**, Nevada (1997-Present). A high temperature (above water boiling) heater test conducted in highly fractured unsaturated rock

- Full Scale Engineering Barriers Experiment (**FEBEX**), Grimsel Test Site, Switzerland (1997-2003). A large-scale heater test in a bentonite-buffer and rock system.

- **Kamaishi Mine** heater test, Japan (1995-1998): A heater test in a bentonite-buffer and fractured rock system

- Hydraulic injection test in a 1700-meter deep borehole at the Laxemar site, **Äspö Hard Rock Laboratory**, Sweden (1995-1996): Injection tests for *in situ* determination of normal stiffness of natural fractures and for studies of coupled HM effects during hydraulic stiffness measurements.

INTERNATIONAL RESEARCH COLLABORATIONS

Active in a number of international collaborative projects, starting with DECOVALEX project on development and validation of coupled models, a project that has been ongoing since 1992 with high scientific output, including journal publications and books. Hosted over the past 15 years numerous international visiting scientists and students at the LBNL and thereby fostering long-term research collaborations in the field of coupled processes in geological media.

2003-Present Collaboration with a number of international researchers on the development of linked TOUGH and FLAC simulations for coupled reservoir-geomechanical analysis under multi-phase flow conditions.

2011-Present Collaboration with AIST, Japan for modeling of coupled geomechanical processes and ground surface deformations associated with underground CO2 injection using the TOUGH-FLAC.

2011-Present Collaboration with the Korean Institute of Geosciences and Mineral Resources (KIGAM) on compressed air energy storage and thermal storage in underground caverns.

2011-2013 Partner in the In Salah Joint Industry Project for CO2 storage, Algeria, including BP and Statiol for the geomechanical analysis associated with the CO2 injection.

2009-2011 Collaboration with Taisei Corporation, Japan for modeling of coupled geomechanical processes and ground surface deformations associated with underground CO2 injection using the TOUGH-FLAC.

2009-2011 Collaboration with Taisei Corporations, Japan for modeling of coupled THM processes in engineered barrier systems using TOUGH-FLAC and the Barcelona Basic Model for unsaturated clay behavior in the Japanese nuclear waste program.

2006-2007 Joint research project on 1960s Matsushiro Earthquake Swarm as a natural analogue for CO2 storage and leakage with Mizuho Info and Research Institute, funded Ministry of Trade and Industry Ministry (METI) of Japan.

2004-2010 Collaboration with the Geoscience Azur Laboratory, and University of Nice, France for modeling of coupled processes at the Coaraz fractured rock site in Southern France.

1991-Present Active in a Research Team as well as Task Leader for the international collaboration project **DECOVALEX I, II, III**, **THMC**, **2011, and 2015** (Development of COupled models and their VAlidation against EXperiments in nuclear waste isolation). The project currently involves over 40 Research and Funding agencies in 9 countries. Research Team on the behalf of Funding Organizations in Sweden, USA and U.K.

2000-2002 Active as a Research Team in an international code comparison project for numerical models related to **geological sequestration of greenhouse gases**. The project involves 10 Research Organizations in 7 countries. Also task coordinator for Test Case on hydromechanical aspects.

1991-1995 Technical Secretary and task coordinator of the international collaboration projects **DECOVALEX** I and II (Development of COupled models and their VAlidation against EXperiments in nuclear waste isolation). The work included arrangements of international workshops, technical coordination and reporting of work conducted by 10 Research Teams in 8 contras.

AWARDS AND OTHER PROFESSIONAL ACTIVITIES

2013 American Rock Mechanics Association Applied Rock Mechanics Research Award for work for work related to modeling of fault reactivation and seismicity associated with geologic CO2 sequestration.

2012 Thesis committee member for Ph.D. defense on “Thermo Hydro Mechanical Impacts of CO2 Injection in Deep Saline Aquifers" at University of Catalonia, Barcelona, Spain, July 2012.

2011 Faculty opponent for Ph.D. defense on “Tunnel Grouting: Engineering Methods for Characterization of Fracture Systems in Hard Rock and

	Implications for Tunnel Inflow", at Chalmers University of Technology, Sweden.
2010	American Rock Mechanics Association Case History Award for work reported in the paper entitled "Coupled analysis of change in Fracture Permeability during the cooling phase of the Yucca Mountain Drift Scale Test".
2009	American Rock Mechanics Association Applied Rock Mechanics Research Award for work reported in the paper entitled "Fractured rock hydromechanics: from borehole testing to solute transport and CO2 storage" - by the Geological Society, London.
2007	Faculty opponent for Ph.D. defense on "Thermomechanics of Swelling Unsaturated Porous Media-Compacted bentonite clay in spent fuel disposal", at Helsinki University of Technology, Finland.
2007-2008	Member of the Radiation and Nuclear Safety Authority (STUK) review team as an expert on thermo-hydro-mechanical evolution associated with the Finish nuclear waste program.
2006-Present	Member of the Swedish Nuclear Power Inspectorate (SSM) review team as an expert on thermo-hydro-mechanical evolution and rock mechanics associated with the Swedish nuclear waste program.
2003-2007	Research Area Leader on Geomechanical Modeling. Department of Geophysics, Earth Sciences Division, Lawrence Berkeley National Laboratory.
2006	American Rock Mechanics Associations Rock Mechanics Award for paper on "Coupled thermal-hydrological-mechanical analysis of the Yucca Mountain Drift Scale Test".
2005	Opponent (French "Repporteur") for Ph.D. defense on "Coupled Hydromechanical Processes in Heterogeneous Fractures Networks", at University of Nice, France.
2004	Recognition of commitment of performance excellence in contributing to the Regulatory Integration Team effort of the Yucca Mountain Project.
2003	Member of Organizing Committee, International Conference on Coupled T-H-M-C Processes and Modeling of Geosystems, October 13-15, 2003, Stockholm, Sweden.
2001	Outstanding Performance Award—for work on coupled THM processes—Lawrence Berkeley National Laboratory.
1999	Faculty opponent for Ph.D. defense on "Hydro-mechanical Behavior of a Pressurized Single Fracture: An In situ Experiment", at Chalmers University, Sweden.
1996-1997	Wennergren Post-doctoral award (Sweden) for research commitment at Lawrence Berkeley National Laboratory, California.

INVITED TALKS

2014 "TOUGH-FLAC Coupled Fluid Flow and Geomechanical Simulations Related to Geologic CO2 Storage". Invited presentation at the State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, China, December 4, 2014

"Geomechanical Aspects of Geologic CO2 Storage" Invited presentation at Hohai University, Geotechnical Engineering Institute, Nanjing, China, December 8, 2014.

"Modeling Fault Reactivation, Induced Seismicity, and Leakage during Underground CO2 Injection" Invited presentation at the International Energy Agency (IEA) Greenhouse Gas R&D Programme's Monitoring Network and Modelling Network – Combined Meeting, Morgantown, West Virginia, August 7, 2014.

"Modeling of Fault Responses and Induced Seismicity during Underground CO2 Injection". Invited talk at Istituto Nazionale di Geofisica e Vulcanologia) in Bologna (Italy), July 4, 2014.

2013 "Coupled Reservoir-geomechanical Analysis Associated with Geologic CO2 Storage in Deep Sedimentary Formations". Invited special speaker at the 6th International Symposium on In-situ Rock Stress (RS2013), Sendai, Japan, 20-22 August, 2013.

"Recent TOUGH-FLAC Coupled Fluid Flow and Geomechanical Simulations Related to Geologic CO2 Storage". Invited talk at the National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, August 26, 2013.

"Modeling of Fault Reactivation and Induced Seismicity During Hydraulic Fracturing of Shale-Gas Reservoirs". Invited speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 21, 2013.

"Modeling of Coupled Thermal-Hydrological-Mechanical (THM) Processes of Fractured Rocks for Multiphase Flow Applications". Invited seminar at Sejong University, Seoul, South Korea, April 19, 2013.

"Geomechanical aspects of geologic CO2 storage critically important for safety and public acceptance". Invited plenary speaker at the 3rd Korea CCS Conference, Jeju Island, Korea, 13-15 March, 2013.

"Coupled THM Processes During Deep Injection Near Brittle-Ductile Rock Transition at The Geysers Geothermal Field, California" 10th International Workshop on Water Dynamics, Deep Carbon Cycle, and ICDP Japan Beyond-Brittle Project (JBBP). Sendai, Japan, 12-16 March, 2013.

2012 "Modeling of Geomechanical Performance of Sloping Oceanic Hydrate Deposits Subjected Production Activities". Invited presentation at American Geophysical Union (AGU), 2012 Fall Meeting, San Francisco, California December 6, 2012.

"Geomechanical modeling of fault responses and the potential for notable seismic events during underground CO2 injection". Invited presentation at American Geophysical Union (AGU), 2012 Fall Meeting, San Francisco, California, December 3, 2012.

"Coupled THM Processes During Deep Injection Near Brittle-Ductile Rock Transition at The Geysers Geothermal Field, California". Seoul National University, Seoul, South Korea, October 19, 2012.

"Demonstration of an Enhanced Geothermal System at the Northwest Geysers Geothermal Field, CA". Invited talk at the Geothermal Stimulation Workshop Entitled "Reservoir Stimulation Current Understanding and Practice, and the Path Forward", Reno, Nevada, September 28 and 29, 2012.

"Modeling of the Potential Fault Reactivation in CO2 sequestration and Shale Gas Fracking" Invited speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 22, 2012.

"Coupling geomechanics and flow and transport: some recent studies at the Berkeley Laboratory". Invited Lecture at the post-TIMODAZ Workshop, Saint Ursanne, Switzerland, February 6, 2012.

2011 "Stress-versus-permeability relationships of fracture rock from in situ experiments and effects of chemical-mechanical coupling". American Geophysical Union (AGU), Fall Meeting, San Francisco December 16, 2011.

"Geomechanical Modeling and Monitoring of Fault Responses and the Potential for Earthquakes During Underground CO2 Injection". American Geophysical Union (AGU), Fall Meeting, San Francisco December 16, 2011.

"Modeling of Coupled THM Processes in Deep Systems", Invited presentation at the Uppsala Deep Hydrogeology Workshop, Uppsala, Sweden, September 22, 2011.

"Geomechanical Aspects and Modeling Associated with Geological Sequestration of CO2", Invited presentation at University of Uppsala, Department of Earth Sciences, Uppsala, Sweden, September 23, 2011.

"Modeling Coupled Thermal-Hydro-Mechanical-Chemical Processes Associated with Geological Sequestration of CO2", Invited Keynote presentation at the 8th International Conference on Calibration and Reliability in Groundwater Modeling MODELCARE2011, Leipzig, Germany, September 18-22, 2011.

"NW Geysers EGS Demonstration Project", Invited presentation at the 2nd Annual Enhanced Geothermal Systems Conference, San Jose, California, June 29-30, 2011.

"CO2 Sequestration Geomechanics and Modeling" Keynote speaker at American Rock Mechanics Association (ARMA), Unconventional Resources Geomechanics Workshop, San Francisco, June 24, 2011.

2010 "Geomechanical Aspects of CO2 Sequestration and Modeling". Invited Keynote Lecturer of the International Workshop on Numerical Analysis for Geomechanics-Establishing Ceremony for Shi Gen-hua Numerical Manifold Method Research Center in Nanjing, China, October 14, 2010.

"Pre-Stimulation Coupled Geomechanical Modeling Associated with the North West Geysers EGS Demonstration Project". Invited presentation at GFZ German Research Center for Geosciences, Potsdam, Germany, September 24, 2010.

"Geomechanical Aspects of CO2 Sequestration and Modeling". Guest lecture in the framework of rock mechanics II & applied rock mechanics in petroleum engineering, Institute of Petroleum Engineering, Technical University of Clausthal, Germany, September 23, 2010.

"Coupled Non-Isothermal Modeling of Ground Surface Deformations and Induced Seismicity at the In Salah CO2 Storage Operation". American Association of Petroleum Geologists (AAPG) Geoscience Technology Workshop on Carbon Sequestration, Colorado School of Mines, Golden, CO, August 10-12, 2010.

"Modeling of Coupled Multiphase Fluid Flow and Geomechanical Processes Associated with Geologic CO2 Sequestration". Keynote Lecture at the Research Institute of Innovative technology for the Earth (RITE) Technical Workshop on Geomechanics and CO2 Sequestration, Kyoto, Japan, January 22, 2010.

"Status of TOUGH-FLAC and Recent Applications". Invited presentation at Kyoto University, Department of Civil and Earth Resources Engineering, Kyoto, Japan, January 21, 2010.

"Modeling of Coupled Multiphase Fluid Flow and Geomechanical Processes Associated with Geologic CO2 Sequestration". Keynote Lecture at the Research Institute of Innovative technology for the Earth (RITE) Technical Workshop on Geomechanics and CO2 Sequestration, Kyoto, Japan, January 22, 2010.

2009 "Copled Hydro-Geomechanical Modeling of Geological Carbon Sequestration Systems". The 2009 Philomathia Forum on Energy and Environment: Berkeley-Stanford-Beijing U.S.-China Workshop on Carbon Dioxide Capture and Storage, Peking University, Beijing, China, November 11-12, 2009.

"Geomechanical modeling and geophysics associated with CO_2 sequestration." The Society of Exploratory Geophysicists (SEG) Summer workshop in Banff, Canada, August 23-27, 2009.

"Modeling of Coupled Thermal-Hydrological-Mechanical (THM) Processes of Fractured Rocks for Multiphase Flow Applications at Four Major Field Sites." Seoul National University and Korean Institute of Geology, Mining and Materials, Seoul and Taejon, South Korea, March 24, 2009.

"Coupled THM Processes Associated with Geologic CO2 Storage". The Ohio State University Conference on Advancing the Science of Geologic Carbon Sequestration. Columbus, Ohio, March 8-10, 2009.

"Analysis of Thermal-Hydraulic-Mechanical Processes in Porous and Fractured Rocks and Geomechanical Performance of Hydrate-Bearing Sediments." StatoilHydro's Gas Recovery Workshop, Oslo, Norway, 5-6 March, 2009.

"Geomechanical Modeling Associated with Geological CO2 Sequestration." The 1st Workshop of The International Energy Agency (IEA) CO2 Modeling Network, Orleans, France, February 8 to 14, 2009.

Estimating stress-versus-permeability relationships of fractured rock using data from in situ experiments and effects of chemical-mechanical coupling." Special Lecture at the International Conference on Rock Joints and Jointed Rock Masses, Tucson, Arizona, Jan 4-10, 2009.

2007 "Stress-versus-permeability Relationships of Fractures from In Situ Experiments." American Geophysical Union (AGU), Fall Meeting, San Francisco December 15, 2007.

2006 "TOUGH-FLAC: A Computer Simulator for Analysis of Coupled THM Processes under Multi-phase Conditions with Applications to CO2 Sequestration." Mizuho Information & Research Institute, Inc., Tokyo, Japan, September 8, 2006.

2005 "TOUGH-FLAC: A Computer Code for Soil and Rock Mechanics Coupled with Multiphase Fluid Flow." University of Nice, France, November 3, 2005.

PUBLICATIONS

Updated January 2015.

- +350 technical publications, including 126 refereed journal papers and book chapters.
- 2162 citations and h-index = 28 in Thomson Scientific's Institute for Scientific Information (ISI) Web of Science Core Collection (as of February 2015).

Refereed Journal Papers

1. **Rutqvist J.** Fractured rock stress-permeability relationships from in situ data and effects of temperature and chemical-mechanical couplings. *Geofluids*, **15**, 48–66 (2015).
2. **Rutqvist J.**, Dobson P.F., Garcia J., Hartline C., Jeanne P., Oldenburg C.M., Vasco D.W., Walters M. The northwest Geysers EGS demonstration project, California: Pre-stimulation modeling and interpretation of the stimulation. *Mathematical Geology,* **47**, 3-26 (2015).
3. Kim J., Sonnenthal E., and **Rutqvist J.** A sequential implicit algorithm if chemo-thermo-poro-mechanics for fractured geothermal reservoir. *Computers & Geosciences*, **76**, 59–71 (2015).
4. **Rutqvist J.**, Rinaldi A.P., Cappa F., and Moridis G.J. Modeling of fault activation and seismicity by injection directly into a fault zone associated with hydraulic fracturing of shale-gas reservoirs. *Journal of Petroleum Science and Engineering* (online February, 2015), doi:10.1016/j.petrol.2015.01.019, (2015).
5. Hu M., Wang Y., and **Rutqvist J.** An effective approach for modeling fluid flow in heterogeneous media using numerical manifold method *International Journal for Numerical Methods in Fluids*. (published online January 15, 2015). DOI: 10.1002/fld.3986 (2015).
6. Blanco Martín L., Wolters R., **Rutqvist J.**, Lux K.-H., Birkholzer J.T. Comparison of two simulators to investigate thermal-hydraulic-mechanical processes related to nuclear waste isolation in saliniferous formations. *Computers and Geotechnics* (Accepted January, 2015).
7. **Rutqvist J.**, Cappa F., Rinaldi A.P., and Godano M. Modeling of induced seismicity and ground vibrations associated with geologic CO2 storage, and assessing their effects on surface structures and human perception. *International Journal of Greenhouse Gas Control* **24**, 64–77 (2014).
8. Kim H.-M., **Rutqvist J.**, and Bae Wi-Sup. Sensitivity analysis for fault reactivation in potential CO2-EOR site with multi-layers of permeable and impermeable formations. *Geosystem Engineering.* **17**, 253–263, (2014).
9. Wang Z., **Rutqvist J.**, Wang Y., Leung C., Hoch A., and Dai Y. The effect of stress on flow and transport in fractured rock masses using an extended multiple interacting continua method with crack tensor theory. *Nuclear Technology*, **187**, 158-168, (2014).
10. Jeanne P., **Rutqvist J.**, Dobson P.F., Walters M., Hartline C., Garcia J. The impacts of mechanical stress transfers caused by hydromechanical and thermal processes on fault stability during hydraulic stimulation in a deep geothermal reservoir. *International Journal of Rock Mechanics & Mining Sciences,* **72**, 149–163 (2014).
11. Zheng L., **Rutqvist J.**, Liu H.-H., Birkholzer J.T., and Sonnenthal E. Model evaluation of geochemically induced swelling/shrinkage in argillaceous formations for nuclear waste disposal. *Applied Clay Science*, **97–98,** 24–32 (2014).

12. Vilarrasa V., Olivella S., Carrera J., and **Rutqvist J.** Long term impacts of cold CO2 injection on the caprock integrity. *International Journal of Greenhouse Gas Control.* **24***,* 1–13 (2014).

13. Jeanne P., **Rutqvist J.,** Vasco D., Garcia J., Dobson P.F., Walters M., Hartline C., and Borgia A. A 3D hydrogeological and geomechanical model of an Enhanced Geothermal System at The Geysers, California, *Geothermics*, **51**, 240–252 (2014).

14. Jeanne P., **Rutqvist J.**, Hartline C., Garcia J., Dobson P.F., and Walters M. Reservoir structure and properties from geomechanical modeling and microseismicity analyses associated with an enhanced geothermal system at The Geysers, California, *Geothermics*, **51**, 460–469 (2014).

15. Wang Y, Hu M., Zhou Q., and **Rutqvist J.** Energy-work-based numerical manifold seepage analysis with an efficient scheme to locate the phreatic surface. *International Journal for Numerical and Analytical Methods in Geomechanics*, **38**, 1633–1650 (2014).

16. Rinaldi A.P., **Rutqvist J.**, Sonnenthal E., L., and Cladouhos T.T. Coupled THM modeling of hydroshearing stimulation in tight fractured volcanic rock. *Transport in Porous Media* (Published online April 2014). DOI 10.1007/s11242-014-0296-5.

17. Wang Y., and **Rutqvist J.** Operator matrix and non-uniqueness of Beltrami–Schaefer stress functions. *Acta Mechanica*, **225**, 1761–1768 (2014). .

18. Asahina D., Houseworth J.E., Birkholzer J.T., **Rutqvist J.**, and Bolander J.E. Hydro-Mechanical Model for Fracture Development and Fluid Transport in Geomaterials. *Computers & Geosciences*, **65**, 13-23 (2014).

19. Jeanne P., Guglielmi Y., Cappa F., Rinaldi A.P., **Rutqvist J.** The effects of lateral property variations on fault-zone reactivation by fluid pressurization: application to CO2 pressurization effects within major and undetected fault zones. *Journal of Structural Geology*, **62**, 97-108 (2014).

20. Pan, P.-Z., **Rutqvist, J.**, Feng X.-T., and Yan F. TOUGH–RDCA modeling of multiple fracture interactions in caprock during CO2 injection into a deep brine aquifer. *Computers & Geosciences*, **65**, 24-36 (2014).

21. Guglielmi Y., Cappa F., Lanc H., Janowczyk J.B., **Rutqvist J.**, Tsang C.-F. and Wang J.S.Y. ISRM suggested method for step-rate injection method for fracture in-situ properties (SIMFIP): Using a 3-component Borehole Deformation Sensor. *Rock Mechanics and Rock Engineering* **47**, 303–311 (2014).

22. Konstantinovskaya E., **Rutqvist J.**, and Malo M. CO2 storage and potential fault instability in the St. Lawrence Lowlands sedimentary basin (Quebec, Canada): Insights from coupled reservoir-geomechanical modeling. *International Journal of Greenhouse Gas Control*. **22**, 88–110 (2014).

23. Rinaldi A.P., Jeanne P., **Rutqvist J.**, Cappa F., and Guglielmi Y. Effects of fault-zone architecture on earthquake magnitude and gas leakage related to CO_2 injection in a multilayered sedimentary system. *Greenhouse Gases: Science and Technology,* **4**, 99-120 (2014).

24. Rinaldi A.P., **Rutqvist J.**, and Cappa F. Geomechanical effects on CO2 leakage through fault zones during large-scale underground injection. *International Journal of Greenhouse Gas Control.* **20,** 117–131 (2014).

25. **Rutqvist J.**, Zheng L., Chen F, Liu H.-H, and Birkholzer J. Modeling of Coupled Thermo-Hydro-Mechanical Processes with Links to Geochemistry Associated with Bentonite-Backfilled Repository Tunnels in Clay Formations. *Rock Mechanics and Rock Engineering*, **47**, 167–186 (2014).

26. Pan P.-Z., **Rutqvist J.**, Feng X.-T., and Yan F. An approach for modeling rock discontinuous mechanical behavior under multiphase fluid flow conditions. *Rock Mechanics and Rock Engineering*, **47**, 589–603 (2014).

27. Pan P.-Z., **Rutqvist J**., Feng X.-T., Yan F., and Jiang Q. A discontinuous cellular automaton method for modeling rock fracture propagation and coalescence under fluid pressurization without remeshing. *Rock Mechanics and Rock Engineering*, .**47**, 2183–2198 (2014).

28. Rinaldi A.P. and **Rutqvist J.** Modeling of deep fracture zone opening and transient ground surface uplift at KB-502 CO2 injection well, In Salah, Algeria. *International Journal of Greenhouse Gas Control,* **12**, 155–167 (2013).

29. Pan P.-Z., **Rutqvist J.**, Feng X.-T., and Yan F. Modeling of caprock discontinuous fracturing during CO2 injection into a deep brine aquifer. *International Journal of Greenhouse Gas Control.* **19**, 559–575 (2013).

30. Wang Z., **Rutqvist J.**, and Dai Y. A Multi-continuum method for studying the effect of inactive fractures on solute transport in 2-D Discrete Fracture Network. *CMES: Computer Modeling in Engineering & Sciences*, **92**, 539-556 (2013).

31. Wang Z., **Rutqvist J.**, Zuo J., and Dai Y. A modified equivalent permeability model of fracture element and its verification. *Chinese Journal of Rock Mechanics and Engineering* (in Chinese), **32**, 728–733 (2013).

32. Derode B., Cappa F., Guglielmi Y. and **Rutqvist J.** Coupled seismo-hydromechanical monitoring of inelastic effects on injection-induced fracture permeability. *International Journal of Rock Mechanics & Mining Sciences*, **61**, 266–274 (2013).

33. Vasco D.W., **Rutqvist J.**, Dobson P., Oldenburg C., Ferretti A., Rucci A., Bellotti F., Garcia J., Walters M., and Hartline C. Monitoring deformation at The Geysers geothermal field, California using C-band and X-band Interferometric Synthetic Aperture Radar. *Geophysical Research Letters*, **40**, 1–6 (2013).

34. Wang Y. and **Rutqvist J.** Non-uniqueness of Beltrami-Schaefer stress functions. *Journal of Elasticity*, **11**, 283–288 (2013).

35. **Rutqvist J.**, Rinaldi, A.P., Cappa, F., and Moridis G.J. Modeling of fault reactivation and induced seismicity during hydraulic fracturing of shale-gas reservoirs. *Journal of Petroleum Science and Engineering*, **107**, 31–44 (2013).

36. Kim H.-M., **Rutqvist J.**, Jeong J.-H., Choi B.-H., Ryu D.-W., and Song W.-K. Characterizing excavation damaged zone and stability of pressurized lined rock

caverns for underground compressed air energy storage. *Rock Mechanics and Rock Engineering*, **46**, 1113–1124 (2013).

37. Lee J., Min K.-B., and **Rutqvist J.** Probabilistic analysis of fracture reactivation associated with deep underground CO2 injection. *Rock Mechanics and Rock Engineering*, **46**, 801–820 (2013).
38. Zhao Z., **Rutqvist J.**, Leung C., Hokr M., Neretnieks I., Hoch A., Havlíček J., Wang Y., Wang Z. and Zimmerman R. Stress effects on solute transport in fractured rocks: A comparison study. *Journal of Rock Mechanics and Geotechnical Engineering,* **5** 110–123. (2013).
39. Liu H.-H., Wei M.-Y. and **Rutqvist J.** Normal-stress dependence of fracture hydraulic properties including two-phase flow properties. *Hydrogeology Journal*, **21**, 371–382 (2013).
40. **Rutqvist J.**, Leung C., Hoch A., Wang Y., and Wang Z. Linked multicontinuum and crack tensor approach for modeling of coupled geomechanics, fluid flow and transport in fractured rock. *International Journal of Rock Mechanics and Geotechnical Engineering*, 5, 18–31 (2013).
41. Liu H.H. and **Rutqvist J.** Coupled hydro-mechanical processes associated with multiphase flow in a dual-continuum system: Formulations and a sensitivity study. *Rock Mechanics and Rock Engineering*, **46**, 1103–1112 (2013).
42. **Rutqvist J.** The geomechanics of CO2 storage in deep sedimentary formations. *International Journal of Geotechnical and Geological Engineering,* 30, 525–551 (2012).
43. **Rutqvist J.** and Tsang C.-F. Multiphysics processes in partially saturated fractured rock: Experiments and models from Yucca Mountain. *Reviews of Geophysics*, **50**, RG3006 (2012).
44. Mazzoldi A., Rinaldi A.P., Borgia A. and **Rutqvist J.** Induced seismicity within geologic carbon sequestration projects: Maximum earthquake magnitude and leakage potential. *International Journal of Greenhouse Gas Control,* 10, 434–442 (2012).
45. Cappa F. and **Rutqvist J.** Seismic rupture and ground accelerations induced by CO2 injection in the shallow crust. *Geophysical Journal International*, **190**, 1784–1789 (2012).
46. **Rutqvist J.**, Moridis G.J., Grover T., Silpngarmlert S., Collett T.S., and Holdich S.A. Coupled multiphase fluid flow and wellbore stability analysis associated with gas production from oceanic hydrate-bearing sediments. *Journal of Petroleum Science and Engineering*, **92–93**, 65–81 (2012).
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